Mars Reconnaissance Orbiter

Risk Management Plan

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Ross Jones
Project System Engineer

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Jim Graf
Project Manager

JPL

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Jet Propulsion Laboratory
California Institute of Technology

Table of Contents

Document Log

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1. Purpose and Scope

This document describes the risk management plan for the Mars Reconnaissance Orbiter (MRO) Project.

The risk management activities of the MRO project are intended to comply with the applicable provisions of JPL Document D-15951, Risk Management Handbook for JPL Projects, and NPG 7120.5A, NASA Program and Project Management Processes and Requirements. The MRO risk management process will meet JPL and NASA requirements and is intended for use by the MRO project to guide risk management over the project lifecycle.

2. Applicable Documents

NPG 7120.5A	NASA Program and Project Management Processes and Requirements
JPL Document D-15951	Risk Management Policy
JPL Document D-XXXXX	MRO Project Policies

3. Definitions

Risk is the probability of an undesirable event occurring and the severity of the consequences of the occurrence. Risks are classified in the broad areas of implementation and mission risk. Risks can be either programmatic or technical.

Implementation risk is the probability of impact to the cost, schedule, technical and/or programmatic implementation plans, and the severity of the consequence to the project implementation plans.

Mission risk is the probability of impact to one or more of the elements of mission success criteria and the severity of the consequence to the mission success criteria. The mission success criteria are defined in the Project Policies document.

Risk Management is the process by which implementation and mission risk are identified, analyzed, and characterized to support effective and timely action by management for mitigation of these risks. The risk management process includes regular assessment and updating of risk status, and communications of risk status to all project personnel and appropriate NASA and JPL management.

4. Risk Management Objectives

The objectives of the MRO risk management process are:

1. Maximize the probability of achieving the MRO mission success criteria [defined in the Project Policies document] within the constraints of the project budget and schedule requirements defined in the project implementation plan.
2. Support project decision making by providing integrated risk assessments continuously throughout the project life cycle.
3. Proactively identify and assess project risks on a continuing basis throughout the project lifecycle.
4. Communicate risk status to all project and appropriate NASA and JPL management personnel throughout the project life cycle.

5. Risk Management Responsibilities

The MRO Project Manager is responsible for the successful guidance of the project in the presence of significant technical and programmatic risk. The MRO Project Manager has delegated the responsibility for the development and ensuring the overall implementation of the MRO Risk Management Plan to the MRO Project System Engineer (PSE). The responsibilities of the members of the project staff in the implementation of the risk management process are shown in the following table. Actual disposition of risk items is the sole responsibility of the MRO Project Manager.

The MRO Project Systems Engineer has the responsibility for overall risk management planning, including the development and implementation of the MRO Risk Management Plan. MRO system managers are responsible for implementing those portions of the project risk management activity internal to their systems in support of this project level plan. The Spacecraft System and Payload Managers are responsible for ensuring the implementation of a risk management process at their contractors which enables their system's participation in the project level risk management plan. The spacecraft contractor's risk management plan is to be documented in the contract DRD MS-008. Instrument contractors shall create a risk management plan responsive to this plan as well.

MRO Risk Management Responsibilities

Risk Management Planning	PSE
Risk Identification	All project personnel including spacecraft and payload element contractors
Risk Assessment	PSE & MAM
Risk Quantification	Project Staff: SSM, PSM, MOM, PS, MAM, PC and PSE
Risk Mitigation Planning	Affected system manager, PSE and PC
Risk Mitigation Plan Implementation	Affected system manager
Risk Monitoring and Control	PM, PSE and PC
Risk Disposition	PM advised by project staff

SSM = Spacecraft System Manager
PSM = Payload System Manager
MOM = Mission Operations Manager
PS = Project Scientist

MAM = Mission Assurance Manager
PC = Project Controller
PSE = Project System Engineer

6. Risk Management Process

6.1. Risk Management Planning

This plan describes the functions, responsibilities and activities necessary to accomplish effective risk management, and fulfills the requirements of NPG 7120.5A. This plan also describes the process through which the MRO project risks will be identified, evaluated, prioritized and mitigated on a recurrent basis throughout the project lifecycle.

Risk planning is the process of identifying the project's overall risk policy and objectives; defining responsibilities, resources, schedules and documentation required for risk management activities; defining tools and techniques that will be used for risk identification, assessment and mitigation; and defining the relationship of the risk management activities with respect to the systems analyses, configuration control, and reviews. The results of the risk planning process are documented in this Risk Management Plan.

An overview of the MRO risk management process and compliance with NPG 7120.5A is shown in the figure 1.

6.2. Identification of General and Specific Risk Issues

The MRO project staff will identify general areas of risk and concerns at the following strategic points throughout the project. These general risks and concerns [risk drivers] will necessarily be qualitative in nature based upon the judgment of the project staff. These general risk areas will be used to help the project staff focus on areas of future risk and perhaps shift resources to prevent the occurrence of specific risks. During phase A, these general risks will be used to focus phase A studies.

- At the start of phase B, prior to the Initial Confirmation Review
- At the start of phase C/D, prior to the Confirmation Review
- Just prior to the Project Critical Design Review
- Just prior to the Spacecraft ATLO Readiness Review
- After launch, at launch plus 30 days

Concurrent with the start of Phase B, specific risks will be solicited from all project elements. The MRO Risk Appraisal Form [see appendix 1] shall be used to submit risk items. After submission, the information in the MRO Risk Appraisal form will be reviewed and confirmed by the PSE and the effected system manager.

The PSE will also proactively seek to identify risks by interviewing selected project personnel, review systems and subsystems technical analyses [such as Fault Tree Analyses and FMECAs and probabilistic risk assessments (PRA)], and through regular

forums/processes such as weekly team tag-up meetings, problem/failure reports and Monthly Management Reviews (MMRs). All project systems and subsystems shall report on their risks at their MMRs. The consistency provided by the calendar of MMRs is intended to promote rigor in the risk management process and institutionalize it within the project as a regular part of doing business.

Risks that are judged to be "significant" by the PSE in consultation with the appropriate system manager and the MAM will be placed on the project Significant Risk List, SRL. Risks not accepted [assessed to be not significant or probably] for the SRL will be kept in the MRO risk database for later evaluation. Upon entry into the SRL, all risk items will be labeled as **Under Review**. During phase A, the SRL will be in a simple spreadsheet format. Later during Phase B and beyond the SRL will be documented via a web based Risk Data management tool. Preliminary parameters for the SRL include: WBS, Responsible Organization, Category, Description, Threatened Requirement or Capability, Status/Strategy for Mitigation, Risk Owner, Need Date for Decision, Risk Consequences ($) and Probability of Occurrence. It is important to note that any project team member [JPL or contractor] can identify a risk and submit it for inclusion on the SRL.

6.3. Risk Assessment and Categories

Risk assessment is the process of establishing the probability of the occurrence of an identified risk event and the consequence to the project if the event occurs. Risk assessment will be completed by the affected system manager using qualitative ranking of risk items into the Probability and Consequence categories defined below. Consequence categories are based on the mission success and budget/schedule effects. The MRO project may also utilize 3rd parties to perform risk assessments of specific items, where such assessments can not be done internal to the project due to limitations on staffing, technical expertise and/or conflict of interest.

Definitions for Probability of risk occurring

Likelihood Rating	Definition	Probability of Occurrence
High	The current approach can not prevent this situation from occurring.	90%
Significant	Likely to occur with the current approach	60%
Moderate	May occur even with the current approach	30%
Low	Not likely to occur using the current approach	10%

Definitions for Risk Consequence without any mitigation

Rating	Impact Description
High	Minimum Mission Success is not attainable and/or 25% of the unallocated budget and/or schedule reserves are needed to mitigate this risk.
Significant	Minimum Mission Success is put at jeopardy and/or 10% of the unallocated budget and/or schedule reserves are needed to mitigate this risk.

Moderate	Full Mission Success may be put at jeopardy and/or 5% of the unallocated budget and/or schedule reserves are needed to mitigate this risk.
Low	Neither the Full nor Minimun Mission Success is put at jeopardy and/or less than 1% of the unallocated budget and/or schedule reserves are needed to mitigate this risk.

6.4. Risk Classifications and Metrics

Once categorization has been completed in either the Formulation or Implementation Phase, risk classification grades designated by Red, Yellow, or Green will be assigned by the PSE and concurred upon by the Project Manager based on the following combination, Figure 2, of the selected impact/probability categories. Risks designated as green do not represent a mission threat. Risks designated as yellow represent a potential threat to some element of mission success. Risks designated as red represent a significant and likely threat to some element of mission success.

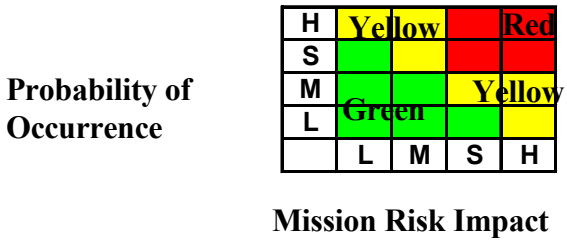


Figure 2 Probability of Occurrence vs. Mission Risk Impact

In the implementation phase quantitative numerical evaluations will be instituted based on probability weighted dollars and the cost of mitigation will be calculated and tracked over time. This indicator and the consultation between the Project Manager and the project staff are integral to the allocation of reserves and priorities for funding liens.

The PSE will review the risk items in the SRL on a periodic basis, at least monthly. The PSE will alert the Project Manager of new risk items or those risk items that have been revised. The PSE is responsible for reviewing risks and providing the Project Manager with timely assessments regarding the recommended disposition of the risk items provided by the system managers. The Project Manager using the project staff as an advisory body, will accept or revise the recommended disposition as described in the Risk Disposition section.

The PSE will be responsible for maintaining the metrics for the risk management process. These metrics will be used as described in the Risk Tracking and Reporting section. The metrics intended for use are:

1. the number of Green, Yellow, Red risks vs. time (Formulation Phase- qualitative assessments)
2. liens against financial reserves and their risk rating (green, yellow, red-Formulation Phase)

3. the project's aggregate risk exposure vs time. (Implementation Phase). This is the sum of the probability weighted cost of risk mitigation shown as a function of time.
4. the evolution of yellow and red risks.

The intended units of Risk measurement for Implementation Phases C/D/E are Probability weighted dollars given by the algorithm:
Risk ($)= P_i * C_i ($)
Where: P_i = Probability of occurrence of Event i
C_i = Cost in dollars to mitigate occurrence of event i

The weighted dollars allow a reasonable amount of reserves to be estimated and accounted against total reserves at the Project Manager level. The risk metrics enable insight into the areas of highest risk and how much the Project Manager will need to spend to mitigate those risks.

6.5. Risk Mitigation Plans

Risk mitigation plans will be created for accepted risks according to their significance i.e. color, using the following approach.

Green Risks

Items classified as green do not need mitigation plans and will be routinely tracked for changes in status.

Yellow Risks

Items classified as yellow may require mitigation plans. For these items alternative strategies will be identified and trade-offs conducted to determine the mitigation required. Future decision milestones will be identified to enable effective tracking of those risks for which immediate action is not deemed necessary. Detailed cost and schedule impacts will be assessed for those risks where mitigation is an option.

Red Risks

Items classified as red are considered primary risk drivers. For these items, mitigation plans shall be created within 2 weeks after the decision to do so. Mitigation plans shall include:

1. a description of the mitigation actions e.g. additional testing, new design, new part, verification plan changes, parallel path developments, requirement descopes to capabilities [plus required waivers]
2. who will perform the mitigation actions,
3. when the actions must start and be complete,
4. the cost and schedule required to complete the actions and
5. a description of the conditions upon which the actions will be deemed successful.

Mitigation plans for Red risks shall be documented in a Project Engineering Memo.

6.6. Verification/Validation of Mitigation

The Verification/Validation of a mitigation plan/action is the responsibility of the area that is responsible for mitigation action. Mitigation plans for Red risks will be "peer reviewed" prior to implementation and "peer reviewed" again after implementation to verify the effectiveness of the mitigation actions. In addition, the Project Manager will review and assess the results of mitigation implementations and verify that the results are truly mitigating. The results of mitigation plan implementation shall be documented in a Project Engineering Memo and in the risk database.

6.7. Risk Disposition

The MRO Project Manager, utilizing project staff recommendations, shall review and disposition risk items as either: **Under Review, Accepted, Controlled, or Retired**. The disposition of Red risk items will be presented to the GPMC for acceptance.

Risk items will be documented as '**Under Review'** when there is insufficient information to classify the risk or the risk has been determined to be yellow and it is not clear that a risk mitigation plan is required. Once the additional information is available or a mitigation plan developed, the risk item will be reprocessed through this disposition process by the PSE.

Risk items will move from '**Under Review'** to '**Accepted'** upon recommendation of the PSE and decision of the PM when it is concluded that there is adequate information to accept the risk without mitigation or accept the need to create a mitigation plan (acknowledging the possibility of residual risk even if the mitigation plan is implemented). Risk items having been documented as '**Accepted'** will be routinely evaluated until they become moot or until the mitigation plan has been created. The financial consequence of accepted liens will be monitored by the Project Controller on "soft liens list".

Risk items will move from '**Accepted'** to '**Controlled'** upon recommendation of the PSE and decision of the PM when one of the following conditions are satisfied:

1. Risk mitigation options that reduce the risk exposure to 'green' have been planned, implemented, and their effectiveness verified. Ideally, all red risks will be driven towards yellow and green, however, the key objective is continued active pursuit of mitigation options and their implementation related to red risks regardless of the residual risk color.

2. All reasonable mitigation options (within cost, schedule, and available technical resources) have been instituted with the result that the risk exposure has changed to 'yellow' and it has been judged by the Project Manager, utilizing the project staff as an advisory body, to be acceptable.

3. Reserves are identified so that, should the risk actually occur, resources would be available to recover from cost, schedule, or technical impacts. Responsibility for accepting liens against reserves resides with the PM.

It is an MRO project requirement to have all red risks dispositioned to '**Controlled'** for each major project review.

Risk items will move from '**Controlled'** to **'Retired'** upon recommendation of the PSE and decision of the PM when the mitigation plan has been successfully implemented and the risk milestones (including the possibility of residual risk) have passed without incurring additional risk. A risk item can also be '**Retired'** when it is clear that either the probability of the risk occurring has gone to zero or the impact of the risk has gone to zero due to changing circumstances on the project.

Retired risks will be archived in the Risk database. A project engineering memo [PEM] shall be written to describe and document the rationale for all risks that have been **retired**.

6.8. Risk Monitoring and Reporting

The Project Systems Engineer has overall responsibility for bookkeeping the disposition of each risk. It is the responsibility of the PSE to utilize the risk management tools and processes, enter newly identified risks into the risk list, and update risk items.

Risk tracking will be supported by a web-based application describing the risk by title, classification, disposition status, as well as other summary data. These summary reports will be available for review in the MRO Risk Management web site.

Risk item documentation is provided by the MRO Risk Management Web site. The Project system managers are responsible for the review of their risk items and the updates of their risk items on an ongoing basis. Once entered into the MRO Risk Management Web site, a permanent record is kept of all risks and subsequent revisions. Only the most recent version of each risk item is viewable via the Risk Management Web site. Past revisions will be made available on a request basis. Requests should be forwarded to the PSE. After a risk has been retired, the MRO Risk Management Web site will lock out further changes. Should changes become necessary a request to the PSE will be required to unlock the record or a new risk item should be created.

All risks that are still active (may still occur), regardless of disposition, will be included on the SRL. Risks that have occurred, or did not occur and have been '**Retired**', will be removed from the SRL and archived in the MRO Risk Management database. Copies of these archived risks are available via request to the PSE.

The PSE will review the SRL on a monthly basis for any changes in risk status or risk item additions. Risk item additions or changes will enter the disposition process discussed previously.

The PSE will provide the project's risk posture at Project Monthly Management Reviews and will provide the input to the Project Manager for Major Reviews as noted in the Project Review Plan. The MAM will present the project's risk posture at the SMAD (Safety and

Mission Assurance Directorate) Reviews. Periodically (at least quarterly) the PSE will present the Project's risk status, upcoming milestones, and highlight risk changes for the project staff and will meet with the Project Manager and Project Controller prior to the GPMC to review and disposition risk items. The Project Manager with consultation from the Project Controller and Project System Engineer can decide to "buy down" the risk exposure by spending reserves to mitigate potential risks depending upon the state of the project financial reserves.

Status reporting at the project MMRs, SMAD reviews and GPMC Reviews and other key management reviews, will include:

1. MRO SRL status
2. The number of Green, Yellow, Red risks vs. time [which provides a qualitative assessment during the Formulation phases of how risk exposure changes with time in each of the green, yellow, and red classifications.
3. Liens against resources and their risk rating (green, yellow, red-Formulation Phase) which provides an assessment of the resource reserves required to cover an accepted yellow or red risk.
4. The project's aggregate risk exposure Probability weighted $ vs. time (Implementation Phase)- which will provide an aggregate risk trend assessment of the project's total risk exposure vs. time.

7. Resources and Schedules

Resources necessary for the development and ensuring the overall implementation of the MRO Risk Management Plan are included in the PSE's budget. Resources necessary to support the risk management process are to be included within each system. A listing of risk management activities and timing is shown in the following table which is related to the project top level schedule shown in figure 3.

Risk Management Activities and Schedule

ACTIVITY	Initial Release Or Start	Application or Update Frequency	Product
Risk Management Plan	4/2/01	As required	Risk Mgmt Document
MRO Risk Mgmt (MRO) database development	Initiation of Phase B	As required	Internet accessible MRO Database
Project Staff Assessments	Initiation of Phase B	Quarterly	Risk Identification and MRO database
PM , PSE, PC, MAM Assessment	Initiation of Phase B	Monthly	Risk Categorization and Metric charts (Probabilty vs Mission risk, Risk trend , Table of green yellow, red, risks)
System Manager Mitigation	Initiation of	As required	Mitigation Plans

Plans	Phase C/D		
Lessons Learned	Initiation of Phase B	Quarterly	Risk Identification and MRO database
FMECA, Fault trees	CDR	As required to assess I/F changes	Single point failure lists, risk Identification and MRO database
Review of MRO Significant Risk List	Initiation of Phase B	Monthly	Reports to Mgmt team and reviews
Assessment of Key Reserves [mass, schedule, budget]	Initiation of Phase B	Quarterly	Monthly and QTRLY Report

8. Project Descope Strategy

Project descopes are a specific risk mitigation to be used to increase margins for critical resources when no other risk mitigation actions are acceptable to the project. The most critical resources against which descopes will be evaluated are mass, cost, and schedule.

The Project Descope List will be created and maintained by the PSE with input from each system manager and reviewed by the PM and PC. Each system manager shall create at least two descope actions for his system. This list will contain a description of the planned descope action, the project resource(s) savings targeted by the descope, a date by which the descope must be implemented to be useful, and other issues associated with the descope. The Project Descope List will be presented at each MMR and GPMC and other formal reviews.

Level I descopes are reductions to the Project Level 1 requirements or mission success criteria. These descopes can only be taken with concurrence of the Project, PI, Program Office, and NASA HQ. Level 1 descopes will be initiated by the Project Manager to the Mars Program when the Project Manager believes this descope is necessary for the purpose of increasing margins or reducing scope / complexity such that the launch date can be met, or the cost commitments can be maintained. Level 1 descopes may also be initiated if the requirement appears to be unachievable for other reasons.

Level II descopes are descopes of the project's Level 2 or 3 requirements. Level II descopes are allowed only if the risks associated with the proposed descope are mitigated to maintain adequate reliability or margins as determined by Project Manager and project margins policies.

APPENDIX 1: Risk Appraisal Form

MRO Risk Appraisal Form

NAME: _____RISK LOG #:_____ DATE SUBMITTED:_____

RISK SYSTEM AREA: FS ___ MS ___ SCIENCE ___ PS____

RISK OWNER: _____

RISK DESCRIPTION:

PROBABILITY OF RISK OCCURRENCE:

High ___	Significant ___	Moderate ___	Low ___
(>90%)	(60%)	(30%)	(10%)

CONFIDENCE* LEVEL HIGH___ MEDIUM ___ LOW____

CONSEQUENCE OF REALIZED RISK:

High ___ Significant ___ Moderate ___ Low ___

CONFIDENCE* LEVEL HIGH___ MEDIUM ___ LOW____

ROM COST IMPACT of REALIZED RISK and WBS (IF KNOWN, K$):

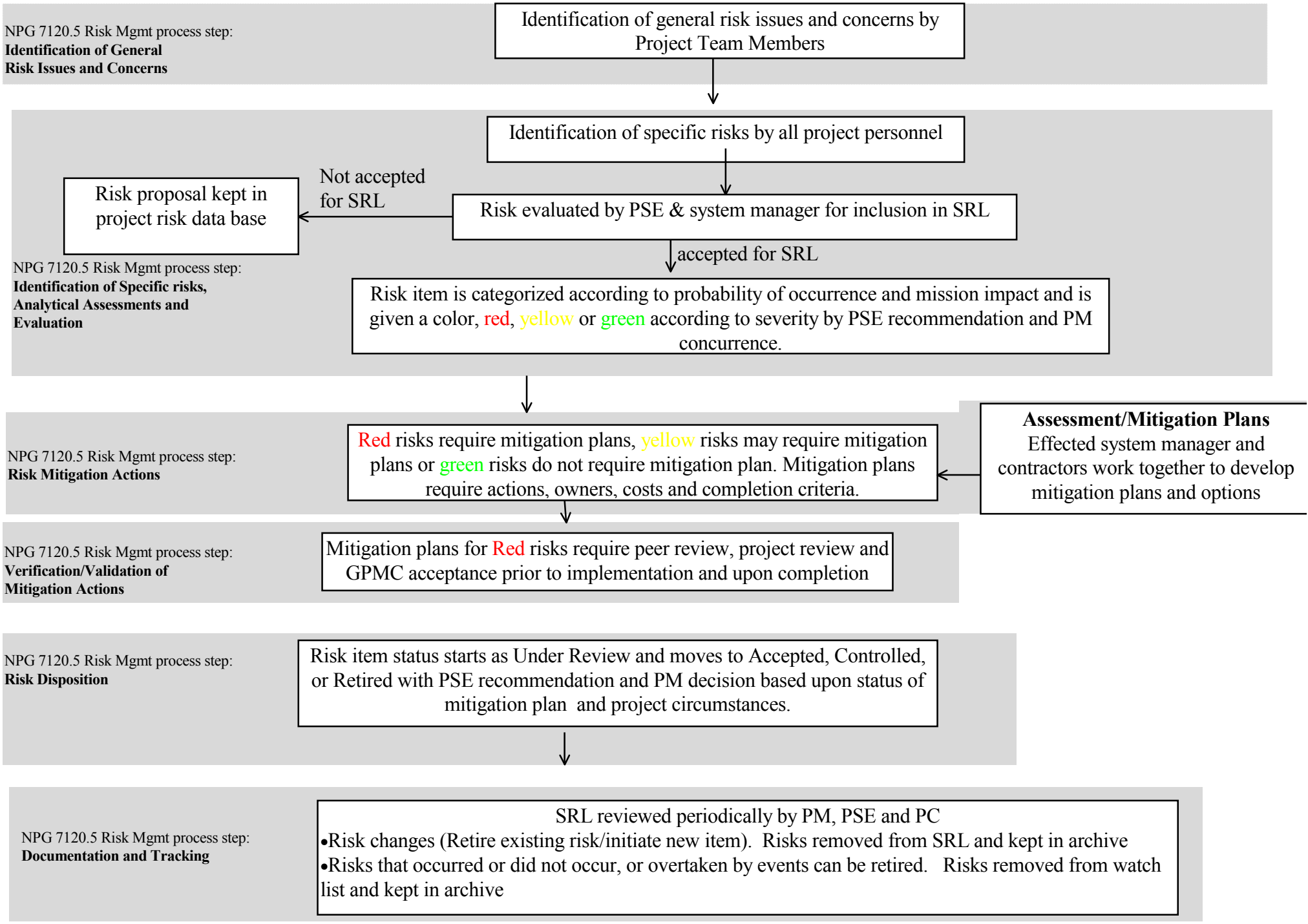
SCHEDULE IMPACT of REALIZED RISK (IF KNOWN, WW):

REQUIREMENT OR CAPABILITY (mass, power, memory, performance, etc, if known) IMPACT of REALIZED RISK

RECOMMENDED RISK MITIGATION ACTION: (description/goal, schedule for action)

* Confidence of the probability or consequence prediction

Figure 1 MRO Risk Management



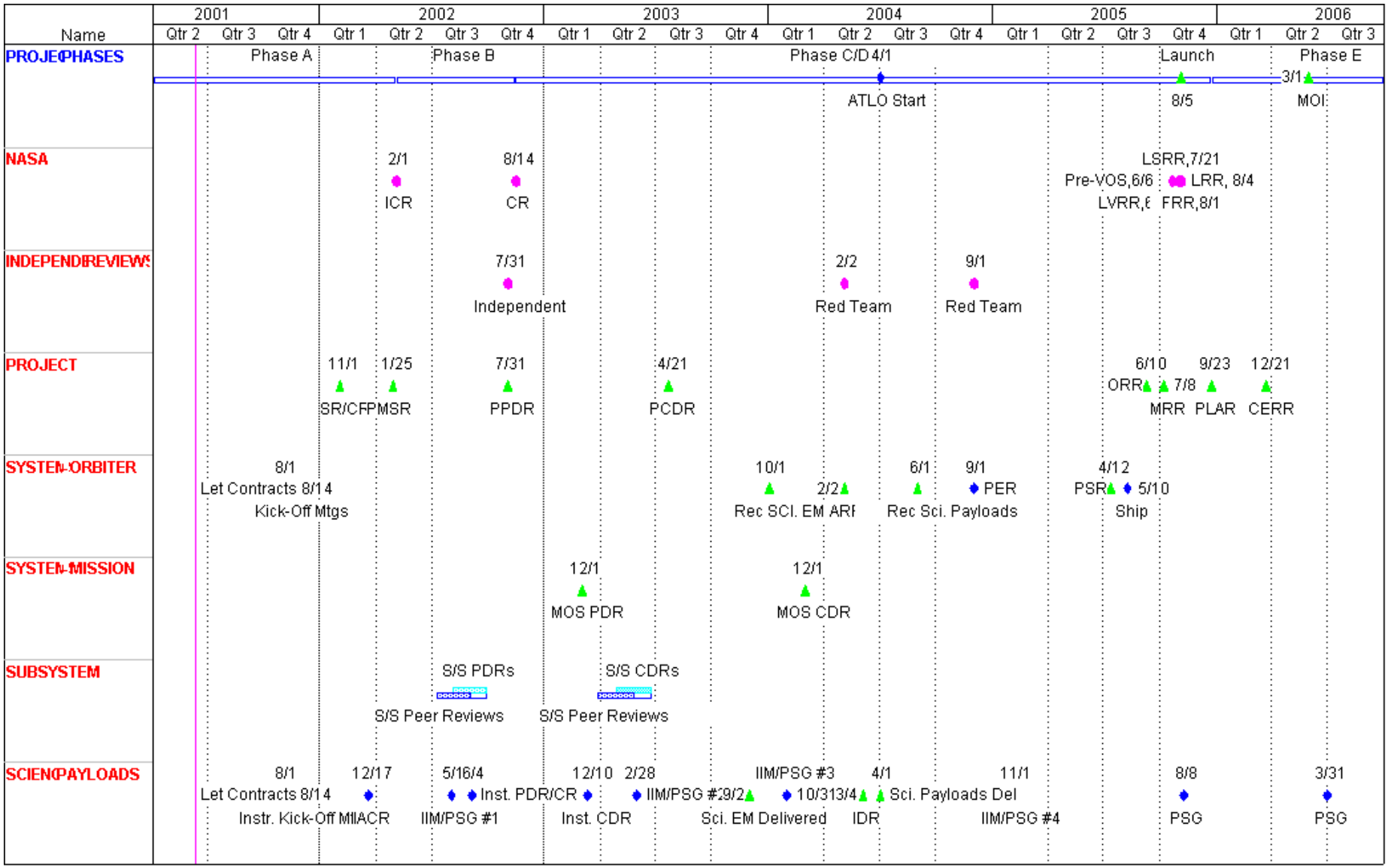


Figure 3 MRO Project Schedule